4.0 REMEDIAL ACTIONS

This section describes the operation of each remediation component of the Carrier Site remedy over the past five years. These components include:

- Institutional controls for land and groundwater use.
- The NRS SVE system.
- The MPA SVE system.
- Point-of-use controls at Water Plant #2.
- Containment of contaminated groundwater using Water Plant #2.

4.1 Institutional Controls

Land use at the CAC Site is zoned industrial. The Town of Collierville has indicated that long-range plans for the area anticipate land use will remain industrial/commercial.

Shelby County prohibits installation of drinking water wells within 0.5 miles of state or federal Superfund sites unless the well owner can demonstrate that the well will not enhance the migration of contaminants (Shelby County Well Construction Code, 4.01[C]).

4.2 North Remediation System (NRS)

The NRS was installed in the former lagoon area during pre-CERCLA response actions in 1989, and has operated continuously since then, except as noted below.

4.2.1 Original Design Specifications

The NRS began as a treatability study at the location of the former surface impoundment, north and west of the manufacturing buildings. Since the treatability test was successful as installed, operation was selected as the long-term Site remedy in this area.

Wells

Well configuration consists of an array of five, 4-inch diameter stainless steel wells installed to recover contaminated groundwater in the shallow aquifer and to allow vapor extraction from the unsaturated soil. The deep wells are screened from the top of the Jackson Clay through the lower 20 feet of the fluvial deposits. Each well has 20 feet of 0.010-inch slot well screen attached to a riser completed to ground surface. The deep wells serve as both SVE and groundwater extraction wells. Bottom-loading, pneumatic pumps deliver groundwater to a rectangular clarifier tank which overflows to one of two surge tanks.

Within the deep well network is an arrangement of four, 2-inch diameter stainless steel wells, screened from 15 to 25 feet below grade. The deep wells are constructed with a 10-foot section of 0.010-inch slot well screen attached to a section of stainless steel riser to ground surface. The shallow wells serve only as SVE wells and do not contain groundwater pumps.

Pumps

Bottom loading, pneumatic pumps were designed to deliver groundwater to a clarifier tank, which overflows into one of two surge tanks. Pump construction is stainless steel and Teflon. A 5-horsepower (hp) compressor at the equipment skid supplies air. Pump cycles are actuated from control-panel mounted pneumatic timers. Well-head solenoids stop air supply to pumps if a float switch does not sense a liquid level in the well.

Water is piped underground from the well vaults to the treatment system through a manifold of polypropylene tubing contained within a 4-inch diameter polypropylene pipe.

Air Stripper Columns

Water flows by gravity from the clarifier into the first surge tank, and is pumped to the top of a 12-inch diameter random packed stripping tower. Packing is 1-inch diameter Jaeger Tripacks, loaded to a bed height of 16 feet. A 2.5-hp blower provides countercurrent airflow in the packing section at 167 cubic feet per minute (cfm), while water is circulated through the packing at a design flowrate of 10 gallons per minute (gpm).

Soil Vapor Extraction

Vapor recovery wells are connected to the central skid by a manifold of 2-inch polypropylene pipes. The deep and shallow wells are manifolded separately and each well head has an isolation valve. The deep and shallow well piping comes together at the surface where it was originally connected to a 5-hp, regenerative type air blower. This blower has since been replaced with a positive displacement blower capable of 180 cfm at 122 inches of water.

4.2.2 Remedial Action Objectives

The remedial action objective (RAO) at the NRS is to prevent migration of contaminants in soil, which would result in Memphis Sand aquifer contamination in excess of MCLs and applicable or relevant and appropriate requirements (ARARs). The 0.533 mg/kg TCE goal developed during the RI/FS and selected as the ROD goal for remediation of the MPA spill area was deemed conservative and therefore was selected as the goal for the NRS.

4.2.3 Current Operating Parameters

Currently the water side of the NRS is not in operation due to a lack of groundwater present in the wells. Once the initial dewatering phase was completed, the NRS well field has remained dry. However, the air stripping system is used to treat extracted groundwater collected at the MPA SVE system.

The SVE system currently operates with both the shallow and deep well manifolds open, however, more vacuum stress has recently been applied to the shallow wells. The regenerative blower was replaced with a positive displacement blower in the fall of 1998. Vacuums generated at the wellhead range from 70 to 120 inches of water, the higher vacuums being generated when the shallow wells were stressed by closing the deep well valve. Discharge temperatures range from 90 to 125 degrees Fahrenheit depending on the outside temperature. Higher discharge temperatures were realized when the vacuum was increased on the shallow well side of the system. The flowrate from the shallow wells averages 25 to 30 cfm, and 100 to 110 cfm for the deep wells.

4.2.4 O&M Evaluation

Required O&M consists of maintenance on the blower only. Drive ends are greased monthly, and oil changed per manufacturer recommendations. The NRS SVE system has experienced very little downtime since it began operation. When it failed after 9 years of continuous operation, the original regenerative blower was replaced with a positive displacement blower in September of 1998.

4.2.5 NRS Site Inspection

Site inspections of the NRS system were performed on June 29, 2000. The objective was to inspect each component of the system and note any changes in operation, components not operating, and normal wear and tear. The NRS is currently operational.

Security

The entire NRS area is secured by a chain link fence with locking gates. The northern part of the fence has a hole in it, large enough for a person to enter. Both gates have locks on them, but can easily be pushed open. Each well is housed in a steel vault, with a steel cover. These vaults are not locked.

Wells

Inspection of each wellhead revealed no damage. All valves are operational. All piping is still in good condition. Down-well inspections were not included as part of this scope.

Pumps

Since the water-side of the NRS is currently not in operation, the pumps were not turned on.

Air Stripper Columns

A visual inspection of the packing material in each stripper column showed no major signs of fouling. However, if this system were to be put back in operation in the future, cleaning of the packing material with an acid wash would be recommended. Both stripper column blowers are operational and showed no signs of excessive vibration or excessive noise.

Soil Vapor Extraction

All wellhead-piping components of the SVE system are in good condition. Isolation valves at each wellhead are operational and sample ports still available. Piping at the equipment compound is in good condition, however, sample ports at the shallow and deep well manifold lines need replacing. The moisture separator was not holding any water at the time of inspection and all threaded connections and the drain valve is in good condition. The SVE blower was operating within its specified range at the time of inspection. The system was turned off and routine O&M performed on the blower. This consisted of greasing of each drive end, checking the oil in the blower, and inspecting the motor belt for wear. Discharge piping after the blower is in good condition.

4.2.6 Permit Compliance

All air permitting at the Carrier facility was performed under Title V (SRC083). Air emissions at the NRS are typically less than 1 pound per day (lb/day) TCE, and the NRS has been identified as an insignificant source area under the Title V permit.

4.2.7 Performance to Date

Operation of the NRS SVE system has resulted in near complete removal of TCE soil contamination from soil identified during the RI. Based on system discharge data, 11,476 lbs of TCE have been removed by vapor extraction since January 1992.

Since January of 1994, vapor samples have been collected quarterly from the NRS. Prior to this date it is estimated that approximately 11,000 lbs of TCE were removed by the system. The reduction in mass removed over the past 6 years (approximately 475 lbs) is typical of SVE system operation where concentrations reach an asymptotic level. A slight increase in mass removed over past years is noticeable since the focus has shifted to the shallow wells. Table 4-1 shows mass removed by quarter at the NRS.

Table 4-1
TCE Mass Removal at NRS

Time Period	Mass Removed (lbs of TCE)
1989 through 2nd Quarter 1995	11,000
3rd 1995	21
4th 1995	14
1st 1996	21
2nd 1996	16
3rd 1996	14
4th 1996	18
1st 1997	12
2nd 1997	18
3rd 1997	15
4th 1997	12
1st 1998	10
2nd 1998	0
3rd 1998	22
4th 1998	95
1st 1999	58
2nd 1999	19
3rd 1999	4
4th 1999	57
1st 2000	52
Total Mass Removed ¾ NRS	**11,476**

Confirmatory soil sampling at the NRS was conducted on December 19 and 20, 1996 at the request of the Site owner. Results indicate the TCE concentration in the soil was generally below the TCE cleanup standard of 0.533 mg/kg. Biased soil sampling was conducted at four locations chosen to present the worst case, at nine depths. Only two samples out of 36 contained TCE concentration in excess of the soil cleanup goal. A singularly high result came in a sample collected at 15 feet below ground surface (bgs) in the northwest corner of the NRS area. The results of the confirmatory samples prompted a focus on the shallow wells, or stressing the shallow soils as opposed to the deeper soils.

4.2.8 NRS Conclusions

Treatment systems at the NRS are functioning as designed. Figure 4-1 shows the mass removed per quarter for the NRS. Mass removal at the NRS area had been decreasing steadily since system modifications were made in 1996; performance was enhanced by addition of a positive displacement pump in 1998.

Evaluation of cumulative mass removal since 1995 is shown in Figure 4-2. The cumulative mass removal graph clearly indicates the NRS system has approached asymptotic conditions several times. Because the 1996 sampling event indicated a majority of samples (34 out of 36) met the 0.533 mg/kg goal at the NRS, and because of the additional mass removal which has

FIGURE 4-1
NRS MASS REMOVED PER QUARTER SINCE 1995

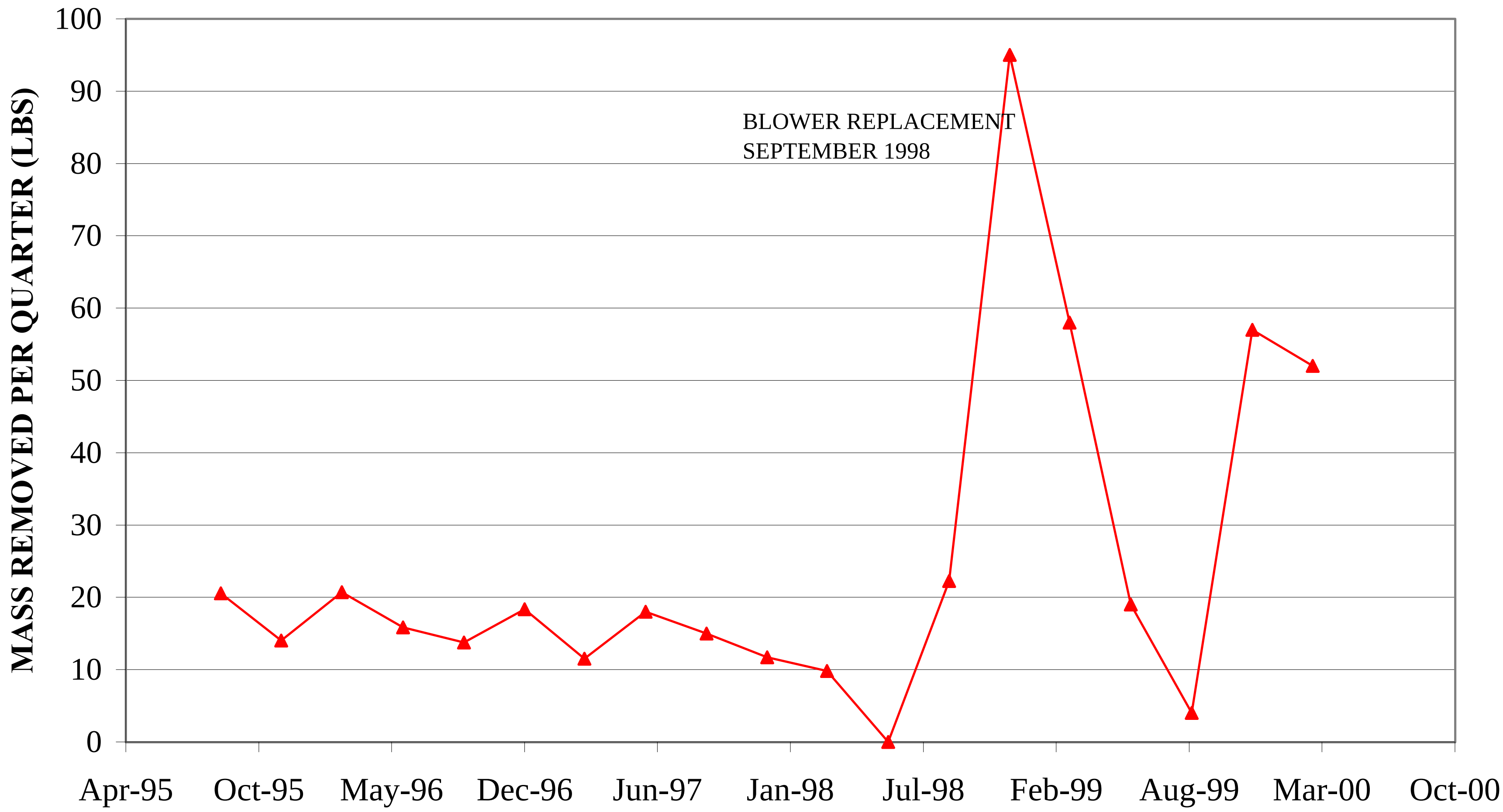
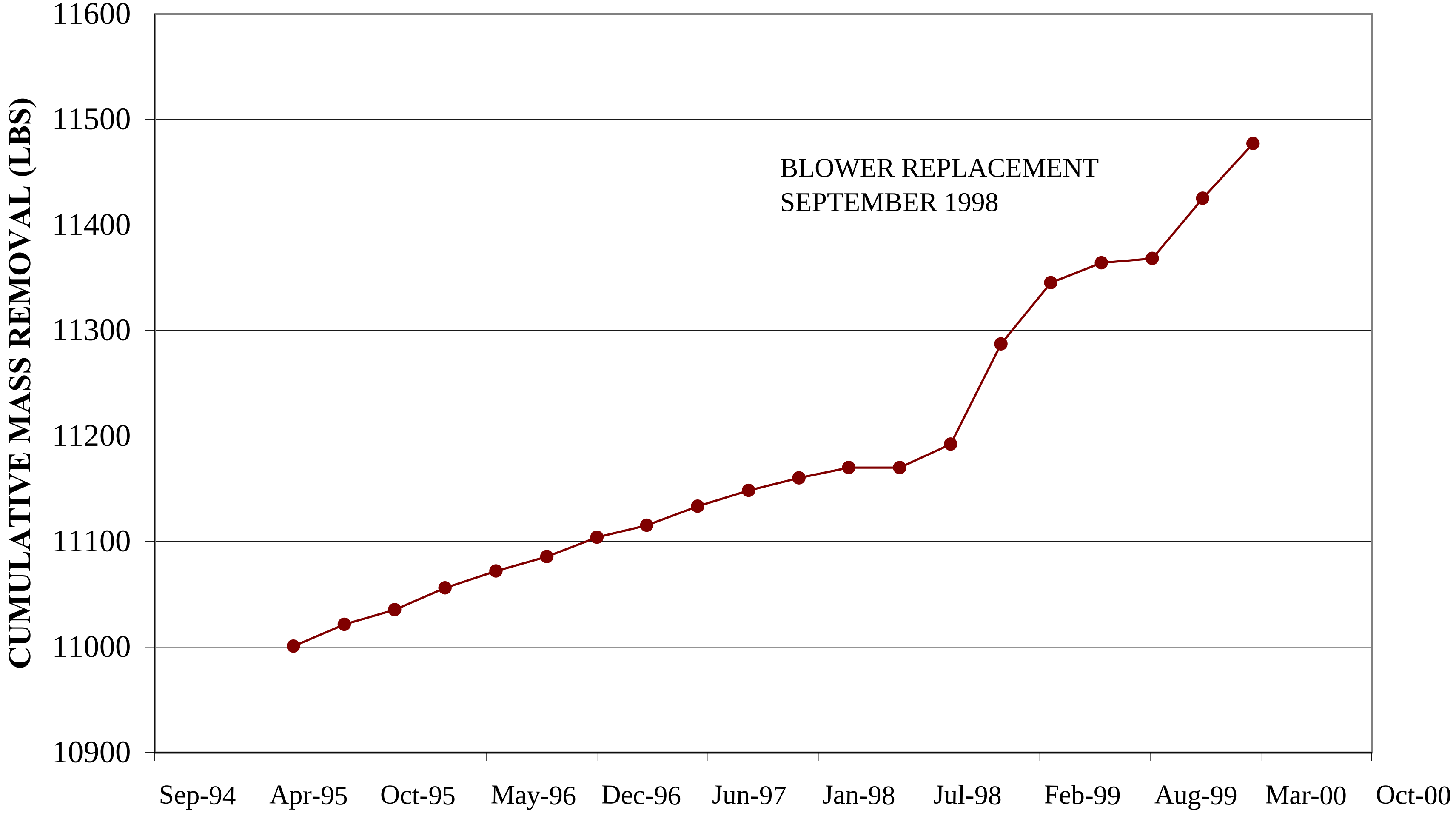


FIGURE 4-2
NRS CUMULATIVE MASS REMOVAL SINCE 1995



occurred since then, additional sampling is recommended at both the NRS area to evaluate the progress of SVE to date.

4.3 Main Plant Area (MPA)

The MPA system was installed during 1994 and 1995, and has been operating continuously since startup, except as noted below.

4.3.1 Original Design Specifications

The SVE system installed in the MPA area was more complex than that installed at the NRS. Its components are described below.

Wells

The MPA SVE system consists of six shallow (depth to 20 feet bgs) wells; one deep (depth to 40 feet bgs) well, and two horizontal extraction wells.

Each vertical SVE well is constructed of 2-inch schedule (SCH) 40 polyvinyl chloride (PVC) piping, with 15-feet of 0.010-inch slotted well screen and riser pipe. The horizontal wells, which run the length of the building from the breezeway east to the edge of the concrete cover, also are constructed of 0.010-inch slotted well screen. Shallow and deep SVE wells are manifolded separately to the equipment compound, where each manifold is fitted with a 4-inch valve for operation. The horizontal wells are also separately manifolded to the equipment compound and contain 4-inch valves for independent operation. The horizontal wells also contain 1-inch valves which can be open to the atmosphere to serve as a passive air inlet when not being used for extraction.

Moisture Separator

Extracted soil vapors first pass through a 40-gallon moisture separator to remove entrained water vapor from the airstream before it passes through the carbon vessels or the vacuum blower. A high-level shutdown addresses situations where too much water has been collected. A drain is manually opened to remove this water from the separator into drums. The contents are then discharged to the air stripper at the NRS for treatment on an as-needed basis before entering the sanitary sewer system.

In-Line Flowmeter

Soil vapor passes through a 4-inch flowmeter. The flowmeter is calibrated to read airflow rate from 10 to 100 cfm. Individual line or well flow can be measured by opening/closing the appropriate manifold valve.

In-Line Heater

Before entering the carbon vessels, soil vapor passes through the in-line heater to diminish the negative effect of relative humidity on carbon adsorption capacity. The heater is operational when the main heater control is on and air is passing through the duct. The heater automatically shuts down by operation of an airflow switch when no air is passing through the duct. A temperature indicator downstream of the heater is used to monitor air inlet temperature into the carbon vessels.

Gas-Phase Carbon Adsorbers

Soil vapor is directed to two skid-mounted gas-phase carbon adsorbers. Each adsorber holds 2,000 lbs of 4 x 10 reactivated carbon, and has 6-inch inner diameter (ID) inlet and outlet flanges and manways for removal/addition of carbon. Vacuum gauges located upstream, between, and downstream of the carbon units are used to monitor pressure drops across the adsorbers.

In-Line Air Filter

The soil vapor passes through a high-efficiency particulate air filter to remove fine-particle solids from the airstream. Pressure gauges located upstream and downstream of the unit are used to monitor the pressure drop across the filter.

Vacuum Relief Valve

The vacuum relief valve is installed to prevent excessive system vacuum. The valve is set to release when line pressure just upstream of the vacuum blower exceeds 170 inches of water.

Air Intake Valve

A provision for dilution air is provided through a filtered intake at the blower. A gate valve is positioned to precisely regulate the amount of make-up air that is fed into the system. Make-up air is necessary for starting the vacuum system under no-load conditions and for operating the system at variable levels of vacuum and vapor flow.

Vacuum Blower

The vacuum blower originally in operation at the MPA was a regenerative pump capable of providing at least 384 cfm under no-load conditions, and capable of operating up to a vacuum of 174 inches of water or 163 inches of water during continuous operation. However, this blower failed on two occasions and was sent back to the manufacturer. The cause, as determined by the manufacturer, was ingestion of foreign material causing the blower to lock (probably very fine soil particulates). After the second failure, the blower was replaced with a 5-hp, positive displacement blower capable of providing 125 cfm at 41 inches of water, or 50 cfm at 190 inches of water.

A high-level signal from the liquid level sensor in the moisture separator will shut down the vacuum blower. A temperature indicator on the discharge piping allows monitoring of the physical conditions of the air discharge stream.

Process Instrumentation and Control

The SVE system can be operated on a timer. Various points in the process are monitored and can actuate a system shutdown, including:

- High water levels in the moisture separator
- Excessive pressure upstream of the vacuum blower

4.3.2 Remedial Action Objectives

The RAO at the MPA is to prevent migration of contaminants in soil, which would result in Memphis Sand aquifer contamination in excess of MCLs and ARARs. The target levels for soil cleanup to prevent soil-to-groundwater transfers is 0.533 mg/kg TCE.

4.3.3 Current Operating Parameters

Based on data from the RI and from installation of the SVE wells, the majority of contamination lies in the shallow, finer-grained soils at the MPA. Therefore, the shallow well manifold is in operation more than the deep well or the horizontal wells. The deep well is only operated occasionally, to degas the sand and gravel zone. From 1995 until June 2000, the shallow wells have operated 861 days, the deep well 228 days, and the shallow and deep well simultaneously 184 days, and the horizontal wells 88 days.

Current operating parameters for each manifold are shown in Table 4-2.

Table 4-2
MPA System Operating Parameters

	Flowrate (cfm)	Vacuum at Blower (in H_2O)	Discharge Temperature (deg F)	Radius of Influence (ft)
Shallow Wells	20 - 25	120 – 130	100 – 170	20
Deep Well	35 – 40	100 – 110	100 – 150	100
Horizontal Wells	25 – 30	100 – 110	100 – 150	Not measured

Air flow is lower in the shallow wells as compared to the deep because the shallow soils consist of silty clays and clayey silts to about 25 feet bgs. This material is underlain by fine- to medium-grained sands to about 40 feet bgs. Permeability data further illustrates why flowrates differ: permeability data from a depth of 13 to 15 feet bgs at the MPA was 3.6×10^{-7} cm/sec, and was 1.1×10^{-3} cm/sec at a depth of 32 to 33 feet bgs. The horizontal wells were installed parallel with the building and completed about 1.5 feet bgs in fill material, and have much longer screen lengths, therefore flow recorded from these wells is also higher than the shallow well network.

4.3.4 O&M Evaluation

Routine O&M of the blower includes monthly greasing of each drive end and changing the oil in the blower. Also, vacuum gauge and flowmeter readings are recorded and compared to previous readings to check for changes. If changes are noticed, the system is adjusted. Table 4-3 shows reasons for the system being shut down, other than routine O&M.

Table 4-3
MPA Downtime Record

Quarter	Downtime Reason
2nd Quarter 1995	Water problem
3rd Quarter 1995	Water problem
4th Quarter 1995	Carbon change
3rd Quarter 1995	Regenerative blower failure; system restarted
1st Quarter 1996	Regenerative blower failure; new positive displacement blower installed
4th Quarter 1996	Carbon change
2nd Quarter 1997	Water problem
3rd Quarter 1997	Carbon change
4th Quarter 1997	Blower belt broken
4th Quarter 1998	Water problem
1st Quarter 1999	Carbon change
2nd Quarter 2000	Water problem

4.3.5 MPA Site Inspection

Site inspections of the MPA system was performed on June 29, 2000. The objective was to inspect each component of the system and note any changes in operation, components not operating, and normal wear and tear. The MPA system is currently shut down due to water entering the wells and manifold piping. The system was turned on for the inspection.

Security

The equipment compound is secured by chain link fencing with a locking gate. Manifold piping from below ground surface is outside of the fencing, but since the area is limited to only plant personnel and Site contractors, it does not appear to have been tampered with. Shallow wells and the deep well are covered with non-locking steel vaults. The wells do not appear damaged.

Wells

A visual inspection of the deep well and shallow wells revealed no significant damage, other than normal wear. All isolation valves within the vaults are operational, and sample ports intact. One shallow well (2D) is bent just above the well vault, however it is still operational.

The horizontal wells were not inspected because they do not have any above ground features/vaults.

Manifold Piping and Valves

Manifold piping from the shallow wells, the horizontal wells, and the deep well are all functional. Each manifold valve is operational. The two air intake valves located on the horizontal wells are operational.

Moisture Separator

The moisture separator lid was removed and the inside of the separator inspected. About 1 to 2 inches of silt or sludge has accumulated inside the separator. Although this does not affect the performance of the separator, this material should be removed. No leaks were noticed on the separator.

In-Line Flowmeter

The system was activated to test the flowmeter. The flowmeter was functional when the deep well was isolated, and flow rates are within the normal range for the deep well. The flowmeter registered slightly when the shallow wells were in operation. However, this is typical of the past performance of the shallow wells. Flows from the shallow wells are typically measured at each shallow wellhead. Again, the flowmeter only registered slightly when the horizontal wells were in operation. This is attributed to water within the line not allowing air flow. Continued operation of the horizontal wells allowed some water to enter the separator, at which time the flowmeter did register.

In-Line Heater

The heater is operating. The downstream temperature gauge was used to check the efficiency of the heater. Initially, the thermostat inside the heater was set to 90 degrees Fahrenheit and the temperature gauge monitored to record when the heater shut down. The heater shut off at approximately 94 degrees

Fahrenheit.

Carbon Vessels

No leaks were found in the piping going into and out of the carbon vessels. The carbon is scheduled to be replaced within the next 2 weeks. The pressure differential before and after the carbon vessels remains at about 6 to 7 inches of water. Valves on the bottom of each vessel were opened to check for water inside. No water was noticed in either carbon vessel.

In-Line Air Filter

The air filter cartridge was removed and found to be in good condition. There were no traces of water or other foreign material inside of the filter housing. The pressure drop across the air filter ranges from 4 to 5 inches of water.

Dilution Valve and Filter

The air dilution valve is operational. The filter housing was removed, and the filter inspected and cleaned. After replacement of the carbon, and the system is turned back on, this filter should be replaced.

SVE Blower

Routine O&M was performed on the blower during the inspection. This included greasing each drive end, and checking the oil level. The motor belt was inspected and found to be in good condition. During the inspection, the dilution valve was completely shut to allow a maximum vacuum condition at the blower. During this operation, there were no signs of leaks or excessive noises or vibrations from the blower.

Alarms

The system was allowed to operate at a vacuum rate of 120 inches of water, as measured at the blower, while the shallow wells were open. During the inspection, water was being extracted and trapped in the moisture separator. After about 1 hour, the separator filled and the system automatically shut down. The system was reset and turned back on.

The blower disconnect was also checked while the system was in operation, and did shut down the blower when turned to the off position.

4.3.6 Permit Compliance

Air emissions at the MPA have been typically less than 1 lb/day TCE, but all emissions are treated with carbon prior to discharge. As noted previously, all air emissions at the CAC facility are permitted through the Title V process (SRC083); the MPA has been identified as an insignificant source.

4.3.7 Performance to Date

The system has operated approximately 74% of the time since the startup of the MPA SVE system on June 1, 1995. The main reason for downtime of the system is the extraction of water that is collected in the moisture separator, temporarily shutting the system down. Since 1995, 716 gallons of water have been extracted by the SVE system. The majority of the water was collected in 1995 (493 gallons) during initial operation of the shallow wells. This water is drained into drums and treated at the NRS air stripper. Extracted water is thought to be coming from underneath the building (Main Plant) and finding its way into the wells and piping trenches of the system.

Soil vapor samples have been collected since the start of the system. Samples were collected monthly from June 1995 through January 1997, then every other month thereafter. On occasion, additional samples were collected to test rebound effects after reactivation of the system if it was shut down, or to assess carbon breakthrough. Since activation of the system, approximately 2,597 lbs of TCE have been removed by the system. Broken down by manifold, this equates to 2,421 lbs from the shallow wells, 142 lbs from the deep well, 34 lbs from the horizontal wells and 0.03 lbs from extracted groundwater. Table 4-4 summarizes the mass removed by the MPA SVE system.

Table 4-4
MPA Mass Removal

Quarter	Shallow Wells (lbs mass)	Deep Well (lbs mass)	Horizontal Wells (lbs mass)	Total
2nd 1995	482.00	0.00	0.00	482
3rd 1995	826.52	2.85	5.48	835
4th 1995	222.00	000	0.00	222
1st 1996	3.04	1.81	0.00	5
2nd 1996	21.04	.97	0.00	22
3rd 1996	14.90	0.00	1.40	16
4th 1996	124.50	11.00	0.00	136
1st 1997	181.00	0.00	0.00	181
2nd 1997	50.00	0.00	0.00	50
3rd 1997	45.00	0.00	0.00	45
4th 1997	37.70	0.00	0.00	38
1st 1998	8.00	0.00	20.14	28
2nd 1998	2.30	2.80	0.00	5
3rd 1998	0.00	0.00	4.00	4
4th 1998	0.97	3.31	3.11	7
1st 1999	66.00	19.00	0.00	85
2nd 1999	16.00	51.00	0.00	67
3rd 1999	149.00	0.00	0.00	149
4th 1999	171.00	0.00	0.00	171
1st 2000	0.00	49.00	0.00	49
Cumulative Total	**2,421**	**142**	**34**	**2,597**

Shallow Groundwater Concentrations

MW-31 is used as an indicator well to measure eventual effectiveness of the soil remediation system in place at the MPA. MW-31 was installed at a depth of 50 feet bgs. The Jackson/Upper Claiborne is absent at this location, indicating the confining unit “pinches out” to the northwest of MW-31. The top of clay contours of the Jackson Clay indicate it slopes radially with a prominent downgradient direction toward the east-southeast (toward MW-31) and to the west. Therefore, contaminants entering the shallow groundwater near the main plant would migrate in a direction toward MW-31.

Groundwater data from MW-31 indicate an overall downward trend since quarterly monitoring began in 1995, and an overall decline in concentration since the RI. Results of quarterly sampling of MW-31 are shown in Table 4-5.

Table 4-5
MW-31 Concentrations

Quarter	TCE (mg/L)
3rd 1995	53
4th 1995	140
1st 1996	170
2nd 1996	19
3rd 1996	67
4th 1996	110
1st 1997	65
2nd 1997	25
3rd 1997	21
4th 1997	65
1st 1998	Not sampled
2nd 1998	14
3rd 1998	52
2nd 1999	19
3rd 1999	45
4th 1999	80
1st 2000	82

4.3.8 MPA Conclusions

The MPA treatment system is functioning as designed. Figure 4-3 shows the mass removed per quarter for the MPA area. Mass removal rates at the MPA have been tailing off since 1996; periodic modifications to the vapor extraction well pattern have augmented removal for the past several years.

Evaluation of cumulative mass removal since 1995, shown in Figure 4-4 indicates the system has approached asymptotic conditions several times. Moreover, decreases in TCE concentrations in MW-31 since the RI indicate that mass contributions to the Memphis Sand from shallow groundwater have been significantly reduced since the installation of the MPA system. Figure 4-5 shows concentration decreases over time.

FIGURE 4-3
MPA MASS REMOVAL PER QUARTER SINCE 1995

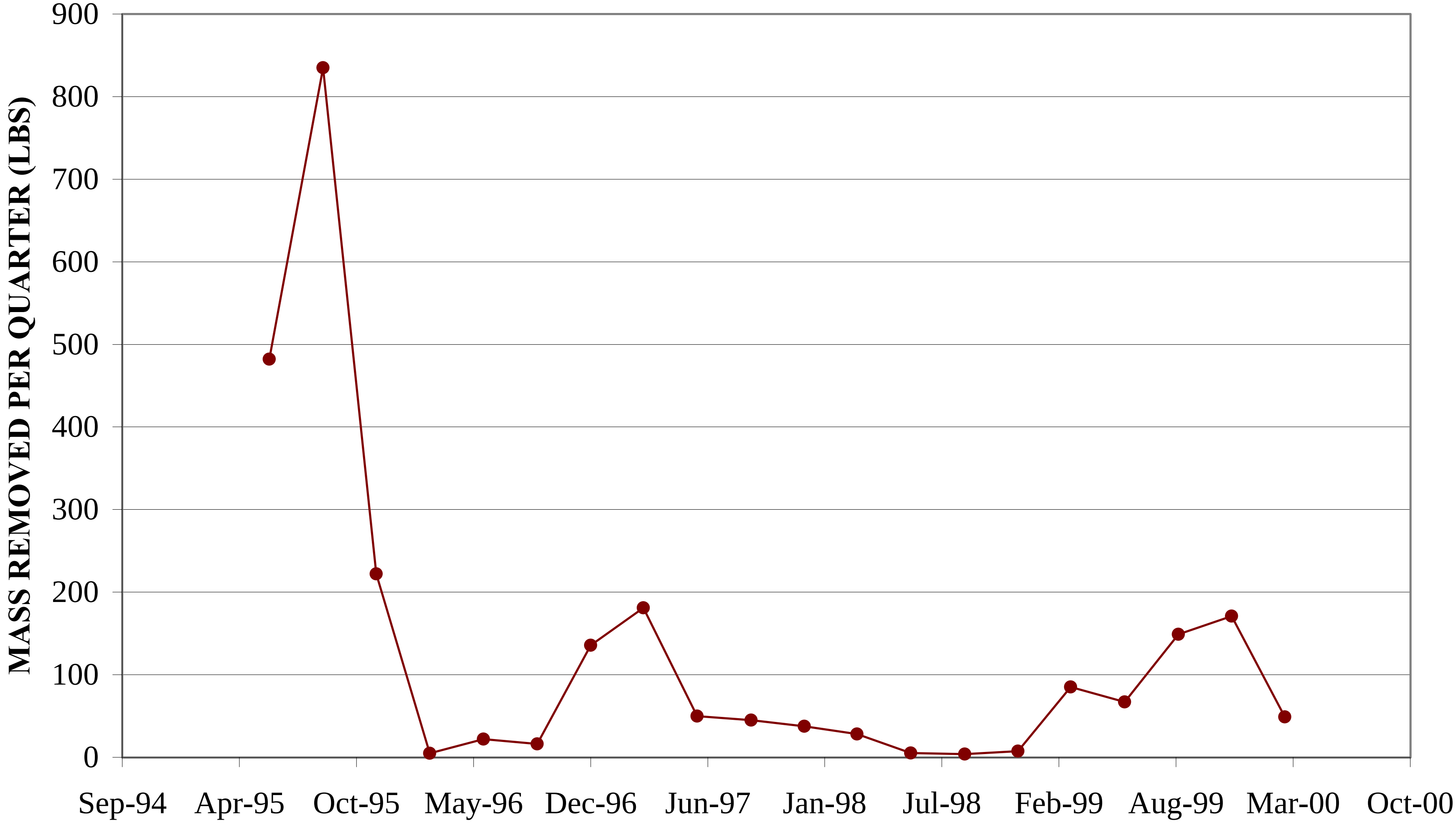


FIGURE 4-4
MPA CUMULATIVE MASS REMOVAL SINCE 1995

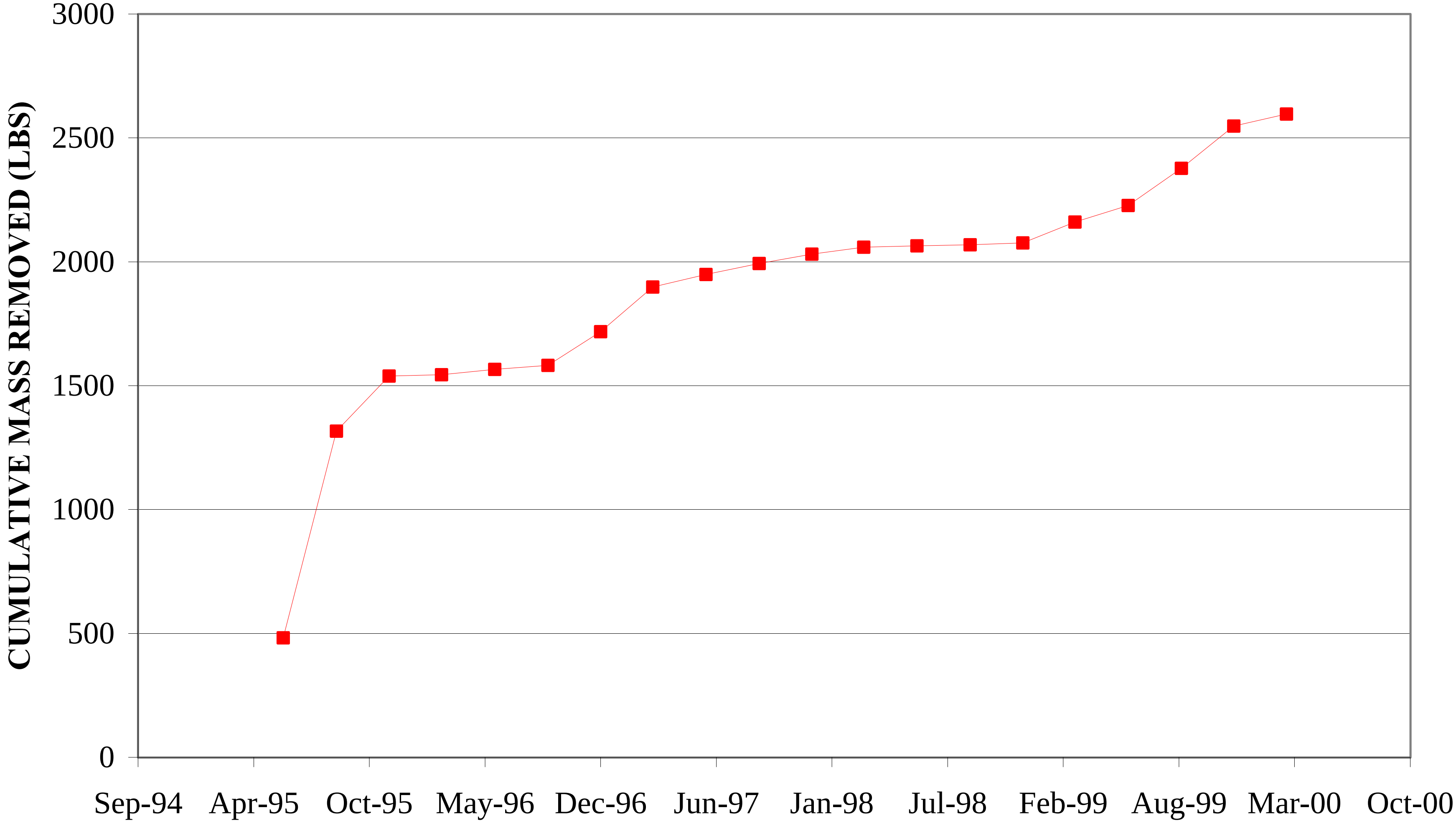
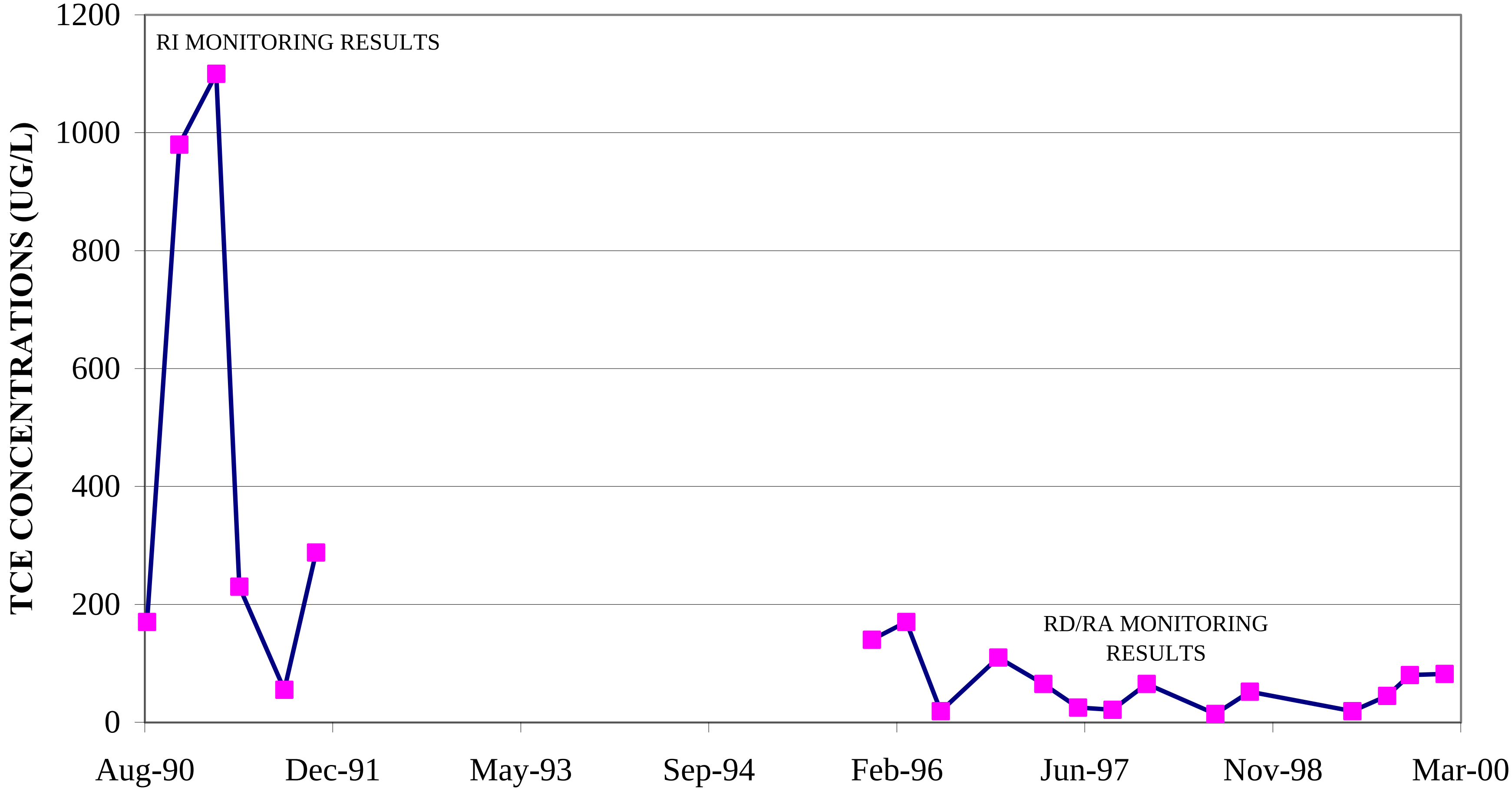


FIGURE 4-5
MW-31 TCE CONCENTRATION TRENDS
AUGUST 1990 THROUGH FEBRUARY 2000



These data indicate that the quantity of TCE being introduced into the Memphis Sand has been reduced by at least one order-of-magnitude since the RI in 1990/1991.

4.4 Groundwater Treatment System (Water Plant #2)

The groundwater treatment system at Water Plant #2 was installed during 1990 to remove TCE from groundwater before it enters the municipal water supply. It has been operating continuously since installation, except as noted below.

4.4.1 Original Design Specifications

In 1990, Carrier and the Town of Collierville designed and installed an air-stripping tower system at Water Plant #2 to treat contaminated groundwater that had reached the Memphis Sand aquifer. This 1.5 MGD system removes TCE from raw water before it enters the chlorination system and allows the town to use Water Plant #2 fully. The treatment system was designed to handle incoming TCE concentrations of up to 300 µg/L. Parameters included for design were based on the operation of one air stripper and are summarized in Table 4-6.

Table 4-6
Design Parameters for Water Plant #2 Air Strippers

Influent Concentration	300 µg/L TCE
Effluent Concentration	≤ 1 µg/L TCE
Liquid Flow	500 gpm (each)
Air Flow	4,500 cfm
Temperature	≥ 50 degrees Fahrenheit
Packing Material	3.5-inch diameter Jaeger Tri-Pack
Tower Height	29 feet
Tower Diameter	5 feet

Wells/Pumps

Groundwater is continually pumped from the two Town of Collierville wells each of which uses a 20-hp, vertical turbine pump rated at 500 gpm. Conditions that stop these pumps include: air stripper blower pressure falls below 0.5 inches water column (indicating blower failure), water in the air stripper sump exceeds 40 inches, or high water levels in the Water Plant #2 above ground storage tank.

Treatment

Once groundwater is pumped from the wells, it is routed to a 10-inch diameter combined influent header, which splits the flow to the two air strippers, depending upon whether both well pumps are running or just one. If both pumps are operating, the combined flow is split between the two air strippers, otherwise flow is directed to only one air stripper. Once pumped water has reached the top of each stripping tower, it enters a distributor to disperse the water over the entire surface area of the packing medium. The water then gravity flows through the packing as air blows in through the bottom of each tower, creating a mass transfer of contaminants from a liquid phase to a gaseous phase, where it discharges through the top of the air strippers.

Treated water is pumped underground to the original water plant equipment. While being injected with chlorine, water is gravity fed from the aeration tower to a 300,000-gallon ground storage tank. Finally, two 800-gpm service pumps distribute the final treated water to the distribution system.

4.4.2 Remedial Action Objectives

The goal of the remedial action is to contain TCE-contaminated groundwater onSite, until cleanup levels for the contaminants of concern are reached throughout the attainment area (e.g., the plume boundary). Cleanup goals for the Site, as established by USEPA and presented in the ROD, are shown in Table 4-7.

Table 4-7
Groundwater Cleanup Levels

Contaminant	Goal (µg/L)
Trichloroethene	5
Cis-1,2-Dichloroethylene	70
Trans-1,2-Dichloroethylene	100
Tetrachloroethene	5
Vinyl Chloride	2
Lead	15
Zinc	5,000

Since quarterly monitoring began in 1995, only TCE has been detected in the Collierville wells; all other volatile organics have not been detected above the method detection limit. Concentrations of lead in the Collierville wells have not been detected above 15 µg/L, and have been below the method detection limit over the past 6 sampling events. Concentrations of zinc have been as high as 68.8 µg/L, however, this may be attributed to the galvanized steel sampling point where the samples are collected and is significantly less than the 5,000 µg/L remedial goal.

4.4.3 Current Operating Parameters

There has been no change in operation of the treatment system at Water Plant #2. Raw and treated water concentrations at the wellheads are monitored quarterly.

4.4.4 O&M Evaluation

Very little maintenance is required of the air strippers and associated equipment, but under an agreement with Carrier maintenance is the responsibility of the Town of Collierville Public Works Department.

4.4.5 Water Plant #2 Site Inspection

The Site inspection of the Water Plant #2 system was performed on June 29, 2000. The objective was to inspect each component of the system and note any changes in operation, components not operating, and normal wear and tear. Only components related to groundwater contaminant removal were inspected, specifically the Town of Collierville wells, air stripper columns, and piping inside the equipment building.

Security

Chain link fencing with locking gates secures both production wells and the treatment building.

Production Wells

A visual inspection of the wells was performed during this inspection. They appear to be in good condition.

Air Stripper Columns

Each air stripper column is equipped with manways to allow inspection of the packing material. During this inspection, only the northern most stripper was checked. The packing material is showing signs of algae fouling, which was noted in 1993. This is not expected to decrease system effectiveness.

Piping and valving inside the equipment building appear to be in good condition. There were no visible signs of leakage. Air stripper blowers are operational and are not creating any excessive noise or vibration.

High/low sump control and blower malfunction safety features were not tested during the inspection.

4.4.6 Permit Compliance

With the exception of ARARs, there are no permits in force to operate Water Plant #2. Approximately 1 lb/day TCE is released to the atmosphere from the air strippers. Emissions from Water Plant #2 are covered under Carrier's Title V permit (SRC083). Water Plant #2 is identified as an insignificant source in the Title V permit.

4.4.7 Performance to Date

Contaminant concentrations in the Collierville wells have been monitored since June of 1990. TCE levels in the Town wells consistently exhibit the same pattern: concentrations in the west well are higher than concentrations in the east well. Raw water concentrations have been slowly increasing in both wells since quarterly monitoring began. Excepting some highs and lows, this upward trend has remained constant, as shown in Figure 4-6.

Mass Removal

Mass removed by Water Plant #2 is calculated from influent concentrations from the Collierville wells, the combined flow from the wells, and the assumption that the air stripper removes 100% of TCE from influent groundwater. Based on these assumptions, Water Plant #2 has removed 3,719 lbs of TCE since the system was installed. Table 4-8 shows pounds of TCE removed per quarter.

FIGURE 4-6
TCE CONCENTRATIONS AT WATER PLANT #2
SINCE SYSTEM STARTUP

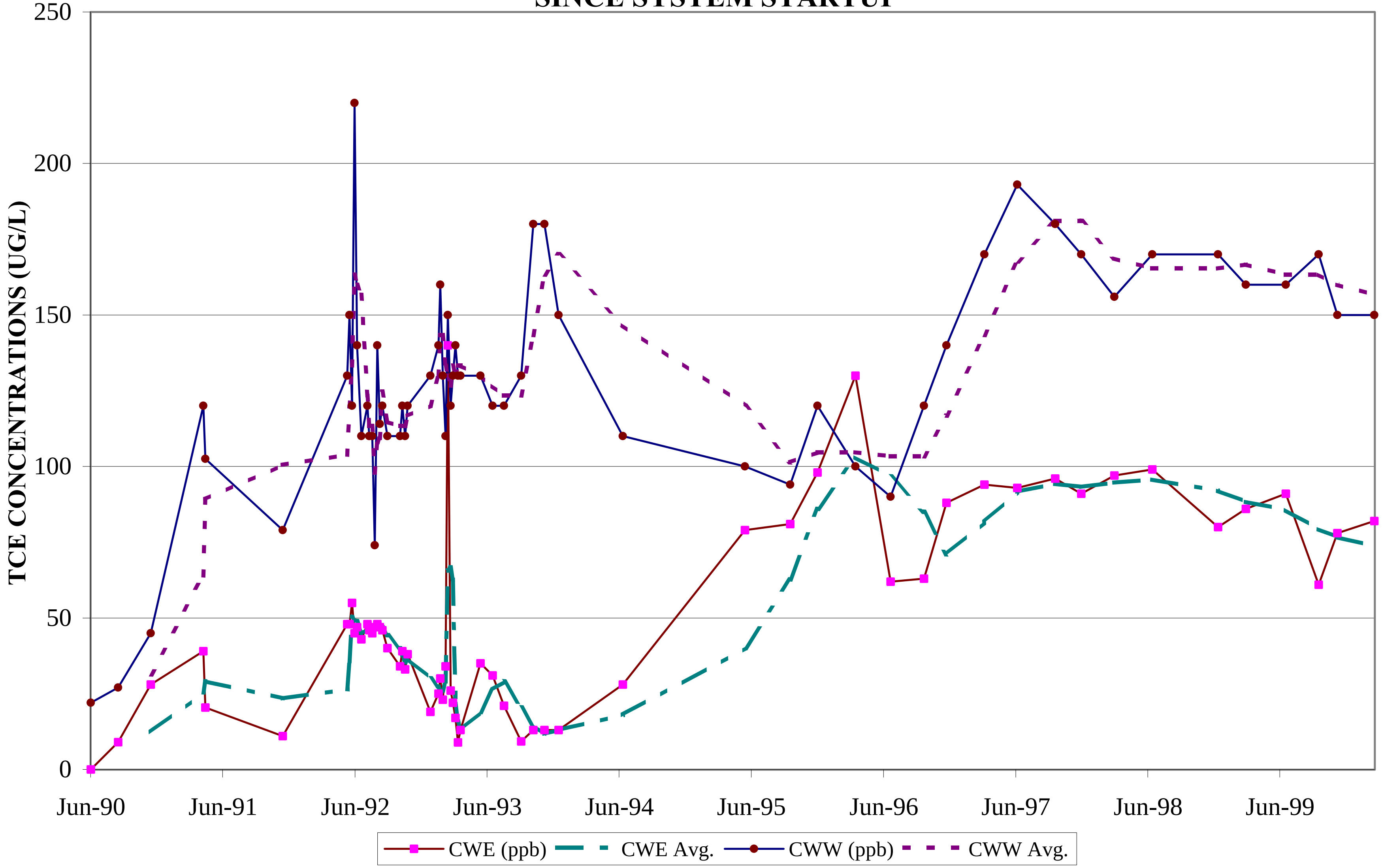


Table 4-8
Water Plant #2 Mass Removal Data

Quarter	Flow Rate (MGD)	Mass Removed (lbs)	Cumulative Mass Removed (lbs)
Pre-1992	Not Available	1,479	1,479
Jun-92	90.7	76	1,555
Sep-92	90.7	60	1,615
Dec-92	90.7	57	1,672
Mar-93	90.7	55	1,727
Jun-93	90.7	58	1,785
Sep-93	90.7	54	1,839
Dec-93	90.7	69	1,908
Mar-94	90.7	Not Available	1,908
Jun-94	90.7	62	1,970
Sep-94	90.7	Not Available	1,970
Dec-94	90.7	Not Available	1,970
Mar-95	90.7	Not Available	1,970
Jun-95	90.7	61	2,031
Sep-95	90.7	62	2,093
Dec-95	90.7	72	2,165
Mar-96	90.7	79	2,244
Jun-96	90.7	76	2,320
Sep-96	90.7	71	2,391
Dec-96	90.7	71	2,462
Mar-97	90.7	85	2,547
Jun-97	90.7	98.1	2,645
Sep-97	90.7	104.1	2,749
Dec-97	85.3	98	2,847
Mar-98	85.9	94	2,941
Jun-98	95.9	104	3,045
Sep-98	96.2	103	3,148
Dec-98	87.9	94	3,242
Mar-99	93	99	3,341
Jun-99	94.9	98	3,439
Sep-99	96.2	97	3,536
Dec-99	97	96	3,632
Mar-00	92.6	87	3,719

Note:
Flow data are not available for pre-August 1997. Estimated, average flow rates of 90.7 MGD were used for these calculations.

4.4.8 Water Plant #2 Performance/Conclusions

The treatment system at Water Plant #2 is functioning as designed; TCE is being removed to concentrations below the MCL by the air stripper system. Figures 4-7 and 4-8 present the mass removal per quarter and the cumulative mass removal at Water Plant #2 for the past 8 to 10 years. These data show mass removal rates are increasing, due to both the increasing contaminant concentrations and the increasing flow rates quantified at Water Plant #2.

4.5 Groundwater Containment

The remedy for the CAC Site uses the existing municipal wells at Water Plant #2 to contain contaminated groundwater in the Memphis Sand beneath the plant. The daily production rate from these wells, during the remedial design, averaged approximately 750 gpm (combined flow), for a total daily flowrate of approximately 1.1 MGD.

4.5.1 Containment Objectives

Modeling performed in 1994 indicated that by maintaining groundwater extraction at Water Plant #2 at these levels, groundwater in impacted areas would be contained. This assessment also evaluated whether groundwater monitoring wells MW-60 and MW-62 (installed downgradient of Water Plant #2) would detect any contamination if containment to the west of the Site was not adequate.

MW-60 was completed to a depth of 385 feet, with a 20-foot screened interval which was completed between 70 and 86 feet below the Town wells' screens. MW-62 was completed to a depth of 200 feet, with a 20-foot screened interval, between 39 and 75 feet above the top of the Town wells' screens. The Town wells are approximately 1,500 feet upgradient of the MW-60/MW-62 pair.

FIGURE 4-7
TCE MASS REMOVAL AT WATER PLANT #2
PER QUARTER SINCE 1992

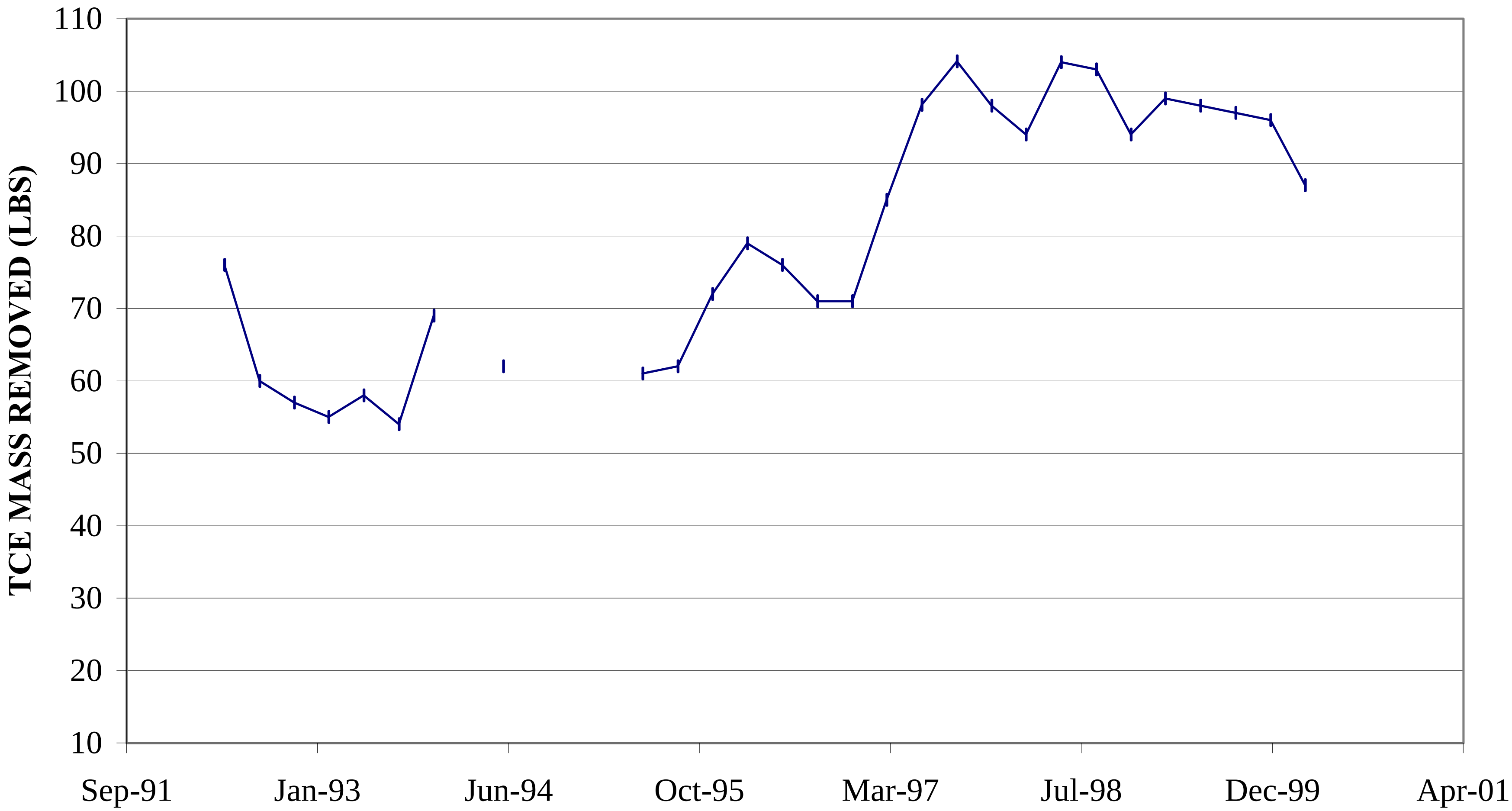
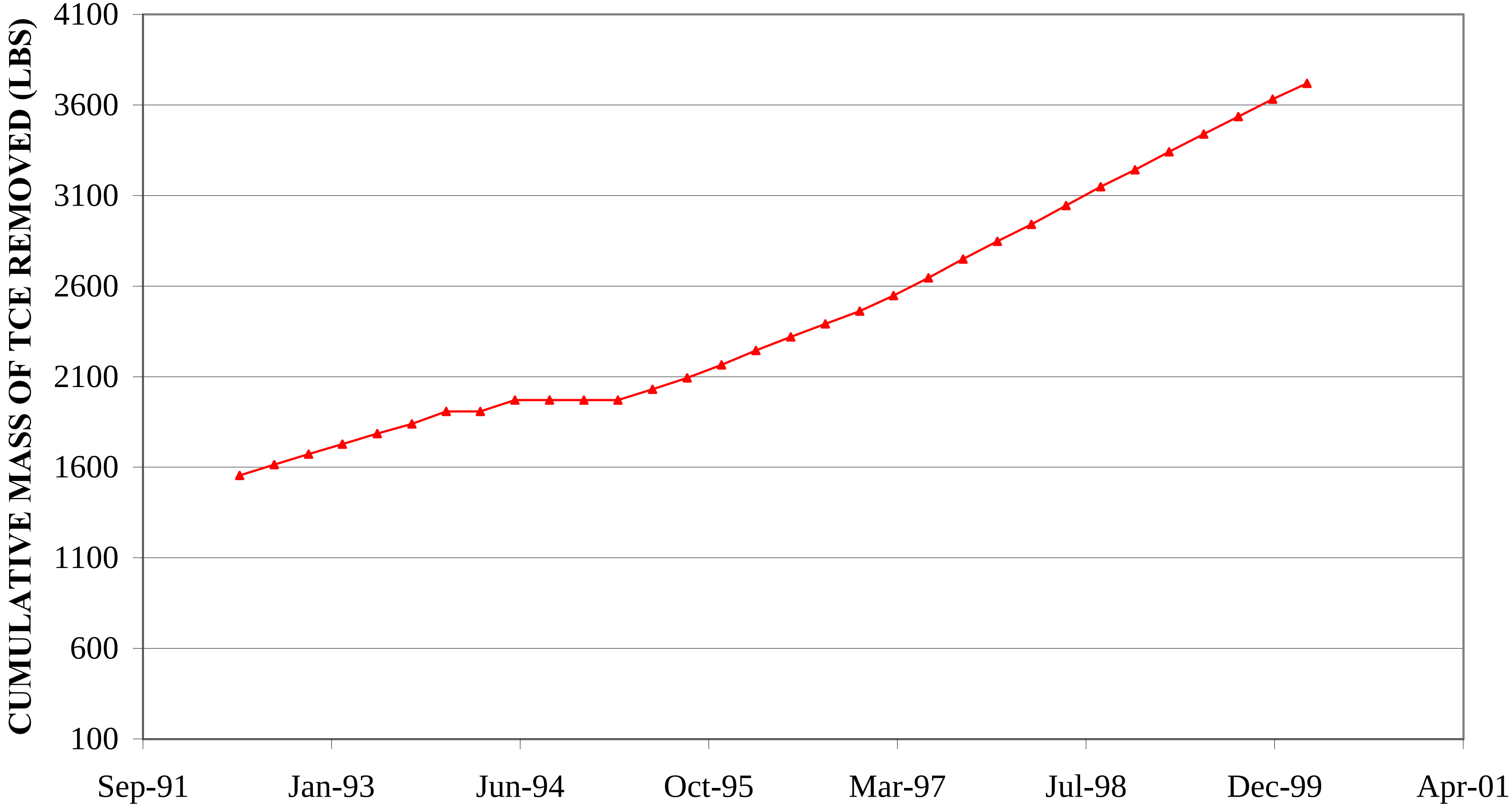


FIGURE 4-8
WATER PLANT #2 CUMULATIVE MASS REMOVAL
PER QUARTER SINCE 1992



Results of hydraulic modeling presented in 1994 were that MW-60 and MW-62 are adequate for monitoring containment because they are located properly downgradient of Water Plant #2 to detect any bypass contaminants, and because any bypass contaminants should have had adequate time to travel from the source area to the monitoring wells.[1] Moreover, the modeling indicated that no additional groundwater extraction was required at Water Plant #2 to effect containment of the plume.

This modeling was repeated during 1996 and 1997, using data obtained during a maintenance shutdown period at Water Plant #2. Groundwater conditions were evaluated under static and pumping conditions. The 1997 verification modeling confirmed the placement of MW-60 and MW-62 as sufficient to detect loss of containment, and also confirmed the adequacy of the Water Plant #2 pumping in containing all contaminated groundwater. The conclusions included the following:

- The static potentiometric surface between the facility and Water Plant #2 indicated a uniform hydraulic gradient between the area where the Jackson/Upper Claiborne unit is absent and MW-60/MW-62.

- The composite capture zone from the east and west wells includes the area of known contamination beneath the Carrier facility.

- With increased water demands from the Town of Collierville, pumping rates are expected to increase, thus causing the composite capture zone to increase in breadth.
- Monitoring wells MW-60 and MW-62 are located downgradient of the Town wells to intercept any contamination flowing along the western edge of the capture zone or moving under the production wells.

Since 1997, there have been no changes in operations at Water Plant #2 or in compliance monitoring data to suggest non-containment.

4.5.2 Water Plant #2 Production Rates

The Collierville wells have maintained production at approximately 1 MGD, with little downtime. Figures 4-9 through 4-12 show daily pumping rates for the period August 1997 through May 2000. These data, obtained

[1] Both modeling efforts were performed to assess containment, particularly along the western edge of the site. Both the 1994 and 1996 efforts demonstrated that adequate containment is provided by the west well, ensuring that no TCE-contaminated groundwater bypasses the Water Plant #2 containment system.

from Town of Collierville maintenance records, are included as Appendix C. Tables 4-9 through 4-12 present monthly flow rate data for Water Plant #2. These data indicate that since August 1997, 74% of all operational days have exhibited flows greater than 1 MGD. The distribution of flow rates is shown in Table 4-13.

Table 4-9
Monthly Production Data for 1997 (in gallons)

Month	Total Water Treated (gallons per month)	Average Water Treated (gpd)	Maximum Water Treated (gpd)	Minimum Water Treated (gpd)
August	35,092,000	1,127,000	1,327,000	625,000
September	34,600,000	1,153,000	1,299,000	1,020,000
October	32,871,000	1,060,000	1,221,000	559,000
November	22,164,000	963,000	1,850,000	42,000
December	30,204,000	975,000	1,084,000	928,000
Averages for 1997		**1,055600**	**1,356,200**	**634,800**

FIGURE 4-9
1997 WATER PLANT #2 DAILY PRODUCTION RATES

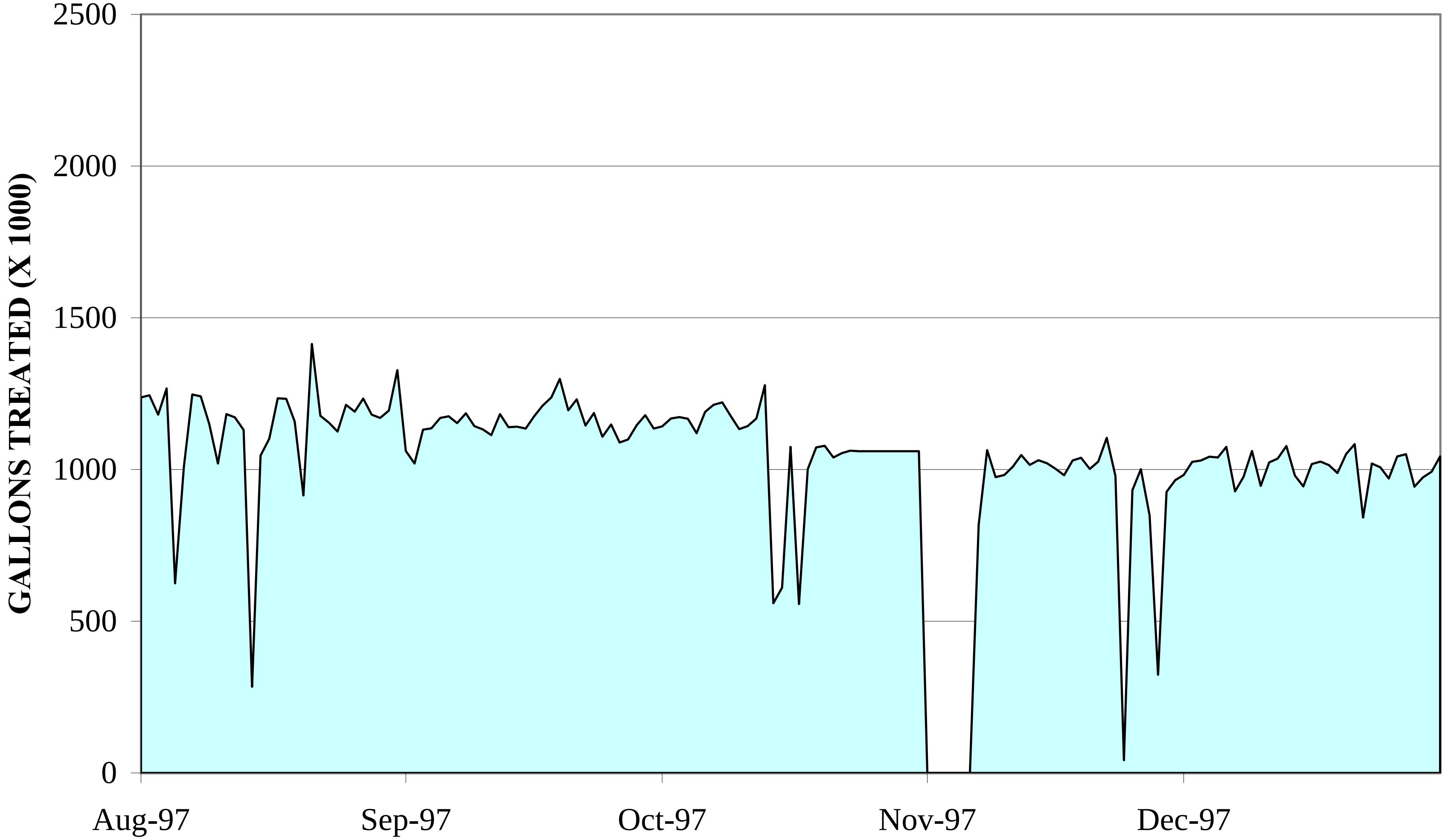


FIGURE 4-10
1998 WATER PLANT #2 PRODUCTION RATES

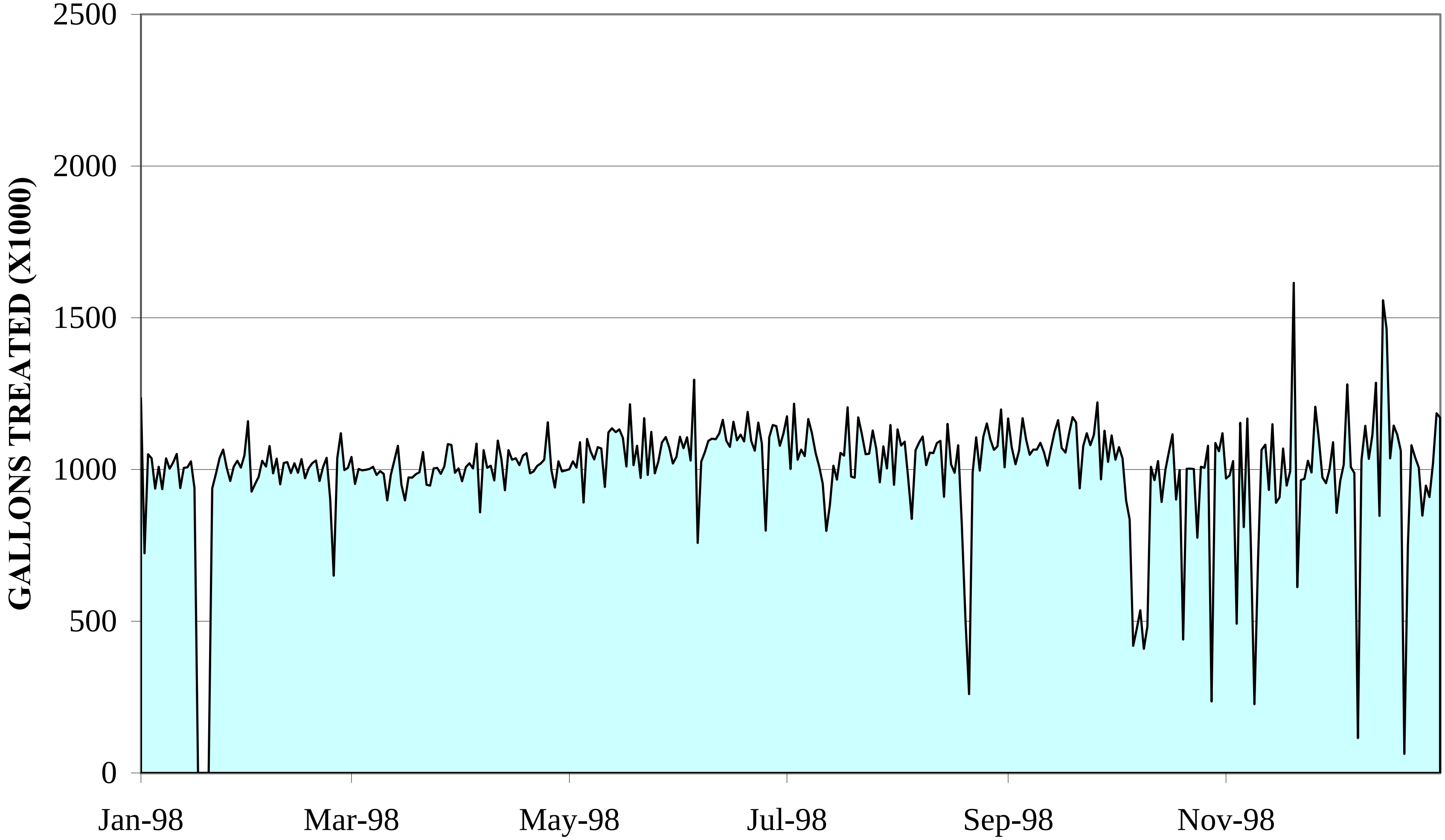


FIGURE 4-11
1999 WATER PLANT #2 DAILY PRODUCTION RATES

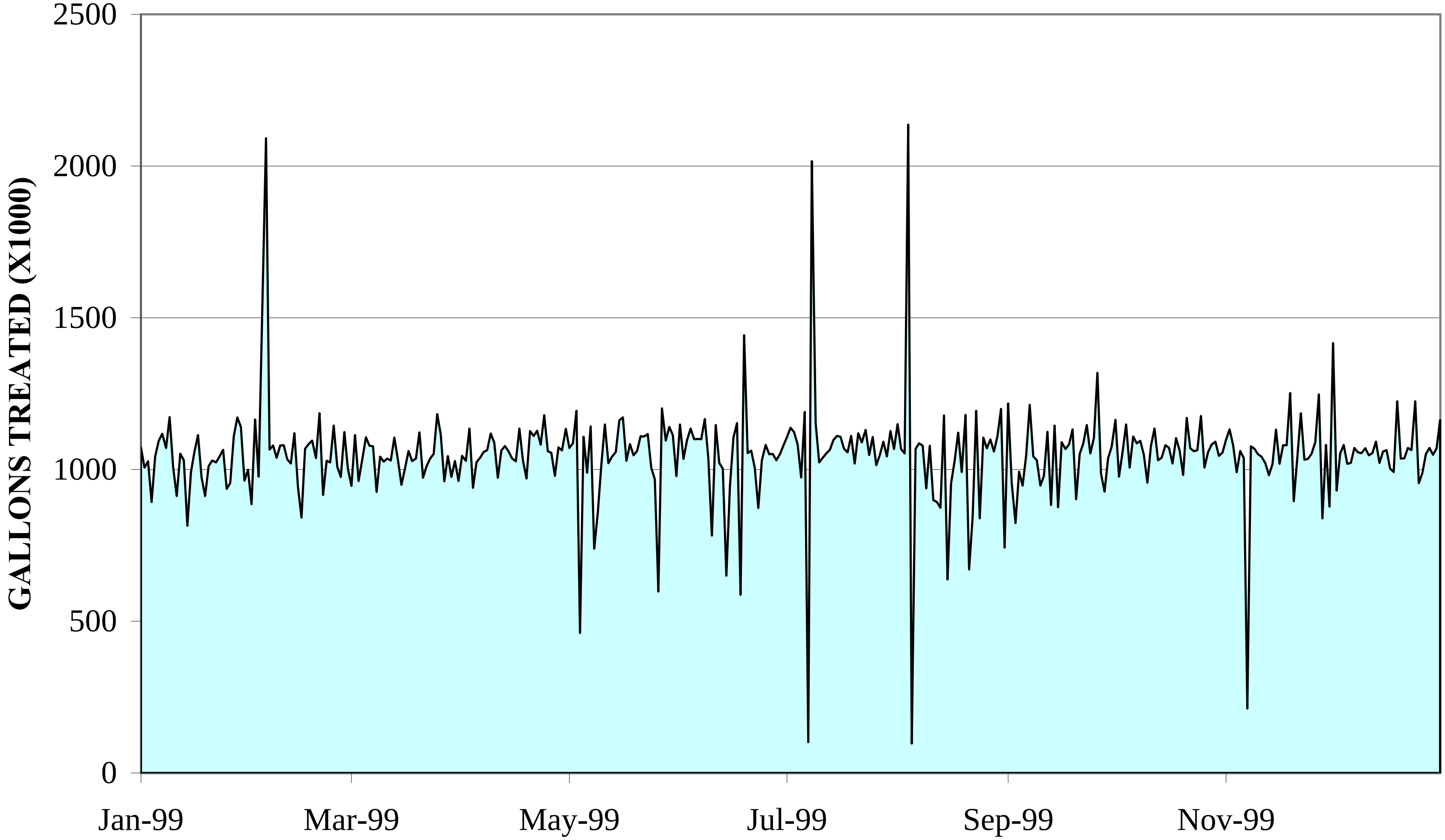


FIGURE 4-12
2000 WATER PLANT #2 DAILY PRODUCTION RATES

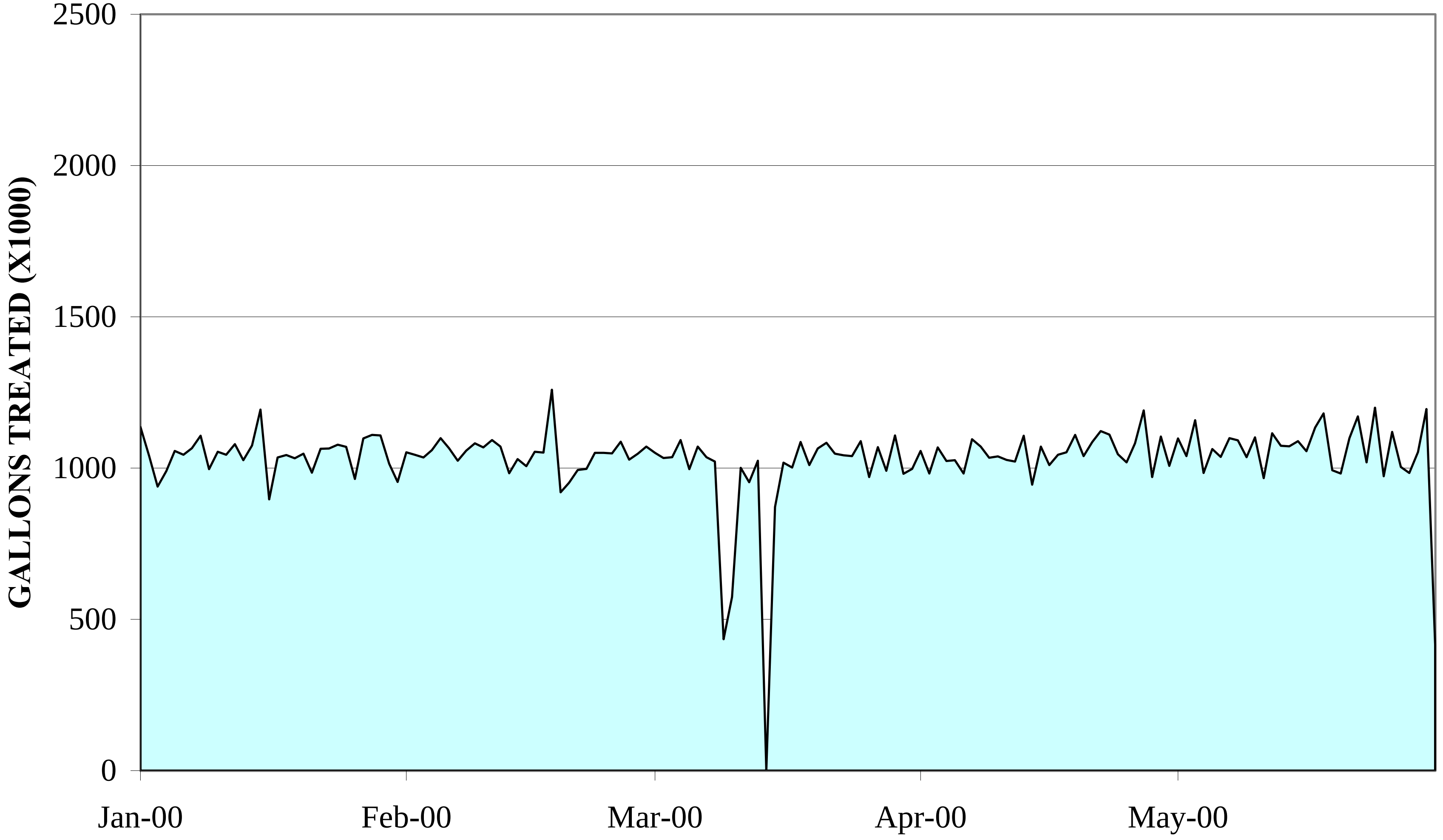


Table 4-10
Monthly Production Data for 1998

Month	Total Water Treated (gallons per month)	Average Water Treated (gpd)	Maximum Water Treated (gpd)	Minimum Water Treated (gpd)
January	27,258,000	879,000	1,235,000	0
February	27,772,000	992,000	1,120,000	650,000
March	30,842,000	995,000	1,084,000	898,000
April	30,452,000	1,015,000	1,156,000	859,000
May	32,817,000	1,059,000	1,215,000	891,000
June	32,638,000	1,088,000	1,296,000	758,000
July	32,480,000	1,048,000	1,217,000	798,000
August	31,204,000	1,007,000	1,198,000	260,000
September	32,641,000	1,088,000	1,221,000	938,000
October	26,984,000	870,000	1,120,000	236,000
November	28,724,000	957,000	1,615,000	227,000
December	32,170,000	1,038,000	1,558,000	63,000
Averages for 1998		**1,003,000**	**1,252,916**	**548,166**

Table 4-11
Monthly Production Data for 1999

Month	Total Water Treated (gallons per month)	Average Water Treated (gpd)	Maximum Water Treated (gpd)	Minimum Water Treated (gpd)
January	31,813,000	1,026,000	1,173,000	815,000
February	29,113,000	1,078,000	2,092,000	842,000
March	32,050,000	1,034,000	1,183,000	926,000
April	31,904,000	1,063,500	1,179,000	940,000
May	31,917,000	1,029,600	1,201,000	461,000
June	31,123,000	1,037,400	1,442,000	587,000
July	33,523,000	1,081,400	2,016,000	102,000
August	31,443,000	1,014,300	2,137,000	97,000
September	31,284,000	1,042,800	1,318,000	824,000
October	33,129,000	1,068,700	1,176,000	957,000
November	30,803,000	1,026,800	1,252,000	212,000
December	33,111,000	1,068,100	1,416,000	931,000
Averages for 1999		**1,047,550**	**1,465,416**	**641,166**

Total 4-12
Monthly Production Data for 2000

Month	Total Water Treated (gallons per month)	Average Water Treated (gpd)	Maximum Water Treated (gpd)	Minimum Water Treated (gpd)
January	32,410,000	1,045,500	1,193,000	897,000
February	30,379,000	1,047,600	1,259,000	920,000
March	29,794,000	961,100	1,108,000	0
April	31,543,000	1,051,400	1,191,000	945,000
May	32,606,000	1,051,800	1,200,000	416,000
Averages for 2000		**1,031,480**	**1,190,200**	**635,600**

Table 4-13
Flow Rate Records, August 1997 through May 2000

Flow Range	# Days in Range	% Operational Time in Range
< 0.8 MGD	50	5%
0.8-0.899 MGD	37	4%
0.9-0.999 MGD	174	17%
1.0-1.099 MGD	511	50%
1.1-1.199 MGD	210	20%
>1.2 MGD	46	4%
Total Days Operational Since August 1997	**1,028**	**100%**

Since 1994, Water Plant #2 wells have been shut down once, from July 24th to August 15, 1996, for maintenance; the total shut-down period was approximately 22 days. Typically, production is never halted more than 1 day at any one time, and the downtime is usually less than a full day due to the Town's water demands

4.5.3 Groundwater Monitoring Program/Effectiveness Monitoring

Groundwater samples have been collected from MW-60 and MW-62 every quarter since their completion. Results of sampling indicate no traces of TCE in either well. The absence of contamination at MW-60 and 62 indicate that capture is maintained at the current pumping rate, shared by the two production wells.

The Water Plant #2 treatment system continues to effectively treat groundwater from the production wells. TCE concentrations in both municipal wells have increased since quarterly monitoring began in 1995, an indication that the containment system is actively drawing the contaminant plume. Peak concentrations were quantified onSite during the pre-RI and RI actions (1988 through 1992). Travel times for TCE in groundwater are expected to be variable given aquifer heterogeneities, but are estimated to be in the range of 10 to 15 years.[1] Therefore, current concentration increases at Water Plant #2 are consistent with shallow groundwater (peak) concentrations below the MPA in the late 1980s and early 1990s.

Source area actions were begun at the MPA in 1995. Groundwater monitoring, reinitiated at MW-31 at the same time, indicated significant decreases in groundwater concentrations since the RI (completed in 1992). Therefore, it is reasonable to expect that concentrations will rise and peak at Water Plant #2 sometime during the next five to ten years, and then start to decline as cleaner groundwater (resulting from source control actions at the MPA) reaches the municipal well field. Mass removal rates at Water Plant #2, therefore, are expected to increase as the main body of the plume beneath the CAC plant is pulled toward Water Plant #2 over the next several years.

It is important to note, however, that heterogeneities in the Memphis Sand aquifer may draw out the peak, and concentrations may not approach MCLs for a long period of time. TCE is expected to remain as residual contamination in the shallower, finer grained portions of the aquifer. These finer grained sediments are likely to be less transmissive than the main Memphis Sand aquifer, and therefore will likely yield less water to the groundwater extraction system than the main producing zone. Once peak concentrations diminish, therefore, it is likely that contamination will diffuse at low levels into the higher transmissivity sands for a long period of time.

4.5.4 Water Plant #2 Performance/Conclusions

The municipal wells are providing adequate containment for the TCE plume, as evidenced by the increasing contaminant concentrations in Water Plant #2 raw water, and the absence of TCE in downgradient monitoring points. Modeling performed in 1994 and 1996 reinforced this conclusion. The increased water demand in the Town of Collierville, as evidenced by the increased daily and peak flow rates, suggests that the composite capture zone developed by the municipal wells will only grow larger.

[1] Travel times to Water Plant #2 modeled using advective groundwater transport were in the 15-year range; however, contaminants were first detected at Water Plant #2 six to seven years after the first spill. Changes in grain size within the Memphis Sand aquifer are expected to contribute to this variability. It is expected, therefore, that actual transport times are variable, in the 10 to 15 year range.